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CERTIFICATION

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EUROPEAN PATENT
0 864 543
in the name of
BETEILIGUNGEN SORG GMBH & CO KG

B. V. Wittken

Dated this **EIGHTEENTH** day of **JUNE** 1999
N-716B

The invention relates to a process for the manufacture of high melting glasses with evaporable components, in particular glasses of the group of boron glass and boron silicate glasses with stages of melting and refining a melt in a furnace with a top furnace with a combustion chamber without internal separating walls, with torches for fossil fuels and with a melting tank having a melting area, a tank bottom and in front of a protruding member and a passage to a discharge member a stepshaped base elevation which is continuous over the entire width of the melting tank.

Carrying out such a process makes considerable demands on details of furnace construction as dictated by glass-chemical processes.

For example, it is stated in the book *"ABC Glas"* (Dr.-Ing. H.-J. Illig; © Deutscher Verlag für Grundstoffindustrie GmbH, Leipzig; 1991; 2nd Edition) on page 36 under the heading *"Borosilikatgläser"* that such glasses, which are used for technical purposes and as equipment glasses of high temperature resistance, have, on the one hand, low expansion coefficients but, on the other hand, require high melt temperatures which reach present day limits of furnace construction. Such glasses have a tendency of evaporating boron and alkali metal oxides and demixing or phase separation (Book *"Glaschemie"*; Prof. Dr. W. Vogel; © Springer-Verlag; 1992; 3rd Edition; Pages 305 to 307) as well as crystallising, all events which result in interference in melting operations.

Due to these properties, the melt processes can hardly be associated with a conventional furnace. Closest to be taken into consideration is the basic principle of the so-called "unit melter" which represents a one-chamber furnace with squareshaped tank cavity and smooth top from where no intermediate walls extend in the heating area in the direction of the melt.

Furnaces of this type are described in the DE-B-2 034 864, US-C-2,800,175, US-C-2,890,547 and US-C-3,353,941. However, it

has been found that such "unit melters" are, without modifications, not well suited for melting boron silicate glasses.

The book by Trier, *"Glasschmelzöfen - Konstruktion und Betriebsverhalten"* (Prof. Dr. W. Trier; © Springer-Verlag; 1984) describes and illustrates on page 11 a boron silicate tank operated at internal arch temperatures of 1,650°C and above, and where a wall is configured on the one hand between the melt and refining part and on the other hand the homogenising part. However, no statements are made about the length of the wall in the flow direction and about the distance of the top edge of the wall from melt level; here again, this wall is positioned behind the refining part, so that it is itself not a refining bank and much too short for satisfactory refining. Details of "unit melters" (transverse flame tanks) are also given on pages 133 and 154.

From EP-B-0 410 338 is known a similar melt unit having in front of a wall a step with two rows of ground electrodes. However, the wall is not a refining bank. The step is to have a maximum height of 100 mm which is less than approximately 15% of a conventional melt bath depth of approximately 800 mm. Furthermore, the step serves only the discharge of possibly present metals in order to prevent short-circuiting between the electrodes. Closable base openings in front of the step serve to discharge such metals. Bubblers are not provided upstream of the rows of electrodes. The electrodes generate a "convection roll" the surface flow of which moves towards the delivery end of the furnace. This is to generate, with reduced furnace temperature, a substance-free melt bath surface, and glass flowing in the direction of the passage is to be held in the area of the glass bath surface for an extended period of time.

In this respect, it is to be mentioned that an increase in glass bath temperature for improved refining is achieved effectively by current only if the current is entered into an area of no or only very little flowback. A strong flow roll would cause severe mixing of the glass

with the other glass which is still being melted, thus putting the temperature increase especially for refining very much into doubt.

From the EP-B-0 317 551, DE-C-39 03 016, US-C-4,882,736 and US-C-4,932,035 it is known to configure in the refining parts above the level of the tank base so-called refining banks and upstream of the refining bank horizontal electrodes in order to increase the refining temperature. However, melting and refining parts are separated by separating walls which extend from the furnace top and which dip into the melt and are thus exposed to high temperature loads and provided with cooling channels.

Bubblers can then be provided in the melt parts; however, due to the separating walls, they do not effect processes in the refining part. As far as melt flow is concerned, melt and refining parts are interlinked by narrow base passages, i.e. by channels which do not extend over the full width of the melting tank and wherein no flow back develops.

DE-C-39 03 016 also refers to the possibility of processing heavily evaporating glasses such as opal, lead and boron glasses, however, without stating how demixing and crystallisation could be countered.

DE-B-1 210 520 reveals, for the purpose of producing a small bath depth, a refining bank which lies higher than the tank base but which comprises at its start an additional step and ahead thereof a dam which protrudes from the melt.

With increasing oxygen content, up to the use of technically pure oxygen, the conditions in the oxidation gas become increasingly less favourable as gas temperatures and reactivity of the gases increase due to higher pollutant concentrations, although the gas volumes reduce. This greatly endangers the refractory materials of the furnace and its supplementary units.

From EP 0 086 858 A1 is known a melting tank for glass which has become known as a "Deep Refiner®", where between a melting zone

which is provided with base electrodes and an even deeper refining zone is configured a base elevation which rises at a slant up to a flat portion, but there is no step or the like. Vertical circulating flows in the form of a plurality of flow rolls are generated by the base electrodes and, if appropriate, additional bubblers in the melting zone. Above the flat portion are arranged additional sidewall electrodes so as to produce the highest temperature in the furnace at that point. Additional electrodes can also be arranged in the low refining zone. However, the flat part then additionally serves as an additional refining zone. Production of melts of high melting glasses with evaporable boron and alkali metal oxides, in particular of boron silicate glasses, is described as sparingly as the feeding of oxygen rich oxidation gases to the torches.

From FR 2 737 487 A1 it is known to arrange in a glass melting tank for flat or float glass production, which is predominantly heated by torches and oxidation gases with a high content of oxygen, between an upstream melting zone and a downstream refining zone the bases of which lie in the same horizontal plane and which are both of identical depth, a base elevation which is continuous from side wall to side wall and which has a trapezoidal cross-section which is described as being important, if appropriate with concave flanks. Due to the effect of the combination of rows of base electrodes configured on both sides of the base elevation and a row of bubblers upstream ahead of the first row of electrodes, two flow rolls of relatively cool glass which are strictly separated from each other are generated on both sides of the ground elevation in the glass melt, and between them a hot zone is generated vertically over the base elevation by means of the base electrodes. This is to prevent a flowback of glass from the refining zone into the melt zone. The height of the base elevation is then maximum half, preferably approximately 1/4 to 1/3 of the depth of the glass bath. A lesser bath depth above the base elevation is explicitly excluded with reference to severe corrosion. Consequently, the base elevation is not a refining bank above which a laminar horizontal flow of little bath depth is conventionally generated, though with increased residence time. Furthermore, there

is no base elevation ahead of the step where electrodes are fitted. The production volume of not high melting glass is to lie between 100 and 1,000 tons per day. The output requirement of the base electrodes of, for example, 1,500 kw is considerable. The separating effect of the combination of base elevation and base electrodes is so considerable that a colour change of the glass melt is possible within the shortest length of time.

It is, therefore, an object of the invention to offer process and a device by means of which high melting glasses with volatile components, in particular those of the group of boron glass and boron silicate glass, can be molten reliably and with high quality and without interference by means of oxygen rich oxidation gases without significant demixing or phase separation and with best possible care of the furnace materials.

The object is achieved with respect to the process according to the invention in that

a) a temperature of at least 1,600°C is produced in the upper furnace by delivering to the combustion chamber an oxidation gas which contains a minimum 50 % vol. oxygen;

b) as base elevation is used a refining bank with an upstream step which is at least 150 mm high and height "H1" of which lies between 0.3 and 0.7 times height "H2" of the refining bank, and from the step protrudes upwardly at least one row of booster electrodes which extends transversely to the flow direction of the melt;

c) the melt is in front of the step guided via at least one row of bubblers located in the tank base; and

d) the melt is behind the step with the booster electrodes in a highly heated state guided over a length of between 800 mm and 2,000

mm via the refining bank, the essentially horizontal top of which is at a maximum distance "T" of 300 mm from the melt mirror.

The length of the refining bank, as seen in the flow direction, is then dimensioned according to the mean residence time of the melt on the refining bank at full load of the tank. This residence time is in turn determined by the duration of the refining process, and the length of the refining bank can be calculated from the throughput and the flow cross-section, i.e. from the flow speed.

At step a), a temperature of preferably at least 1,650°C is generated.

The object is fully achieved by the inventive process. When setting the melt output of the furnace, for example for 40 t/day and with a melt bath surface of 12,200 mm x 3,800 mm, then furnace chamber temperatures between 1,680 and 1,700°C are easily achieved when using technically pure oxygen as oxidation gas. This effectively counters a formation of cristobalite, which can occur for example by evaporation of B_2O_3, by melting the crystals.

The melt area is flow-technically separated from the refining bank by both the row of bubblers and the step with the booster electrodes without requiring any type of separating walls, dams, walls or the like which dip into the melt. In carried out experiments, six bubblers and six booster electrodes are configured in a respective row within the wall gap of the melting tank of 3,800 mm.

Refining of the glass melt is carried out in a thin layer area above the refining bank where the melt arrives at the high temperature required for intensive refining and thus at most favourable viscosity.

Due to relative high flow speed, in the given design averaging 1 m/h, no noticeable B_2O_3-evaporation can take place on the refining bank, so that forming of schlieren and windings which are typical for relevant glasses is practically prevented. Behind the refining bank, the clear melt arrives in a quiescent chamber from where distribution

into the pre-hearths can be carried out. The content of nitric oxides in the waste gases lies way below the legal threshold value.

It is then particularly advantageous if the following conditions are maintained, either individually or in combination:

- A step is used height "H1" of which lies between 0.4 and 0.6 times height "H2" of the refining bank;
- The melt is guided via the refining bank with a mean residence time of between 0.5 and 2.0 hours;
- The melt is guided via the refining bank with a mean residence time of between 1.0 and 1.5 hours;
- The melt is guided in the melting area over a field of base electrodes. In tests, an optimum was found with 12 base electrodes in three rows, where the distance of the rows increases in the direction of the bubblers so that more energy is available thereat where more energy is required for melting. Furthermore, the individual electrode groups can also be separately loaded vertically to the tank axis in order to be able to control or regulate an asymmetry in the transverse direction of the tank and to achieve a symmetrical temperature distribution.

The invention is to specifically prevent forming of a flow roll by the booster electrodes and directly deliver their energy to the refining bank. It is to be observed that the distance of the bubblers to the front edge of the step is designed to correspond with the bath depth and the height of the refining bank as well as the steepness of the viscosity curve or the temperature gradient between surface and base glass. In a normal case, this distance is chosen to be virtually equal the bath depth.

The bubblers cause a flow roll whilst drawing glass from below and transporting it to the surface of the glass bath. Colder glass will then

sink quicker than hotter glass. Within the flow roll, in particular in the flow direction of the glass, a separation of hot and cold glass takes place. The edge of the step then acts like a flow divider, so that colder glass drops, re-enters the root of the bubbler and is of course, due to the mixing effect, partially guided into the flow direction in front of the bubblers.

Hotter glass, which flows above the flow edge onto the half-high step, is then of a higher temperature. Furthermore, due to the fact that the flow cross-section is here already substantially smaller then in a normal glass bath, flowback from this part is already heavily reduced.

Arranging an electrode row on this step, which for practical reasons consists of six electrodes in a row with phases described "R-S-T / R-S-T", relatively even heating of the glass is achieved on this step, combined with an upward flow which ensures that the glass is thereat partially transported to the surface without a significant flowback into the melt tank. It is, of course, possible to operate all electrodes with single phase currents.

This achieves that the temperature of the glass which flows on the actual refining bank is brought to a desired value with the aid of the booster electrodes. This is of importance in particular with boron silicate glass as refining temperatures are required which are substantially higher than with lime-sodium glass. On the other side, however, when the temperature is to be arrived it by entering a lot of energy from the top into the glass bath, evaporation rates are substantially higher than in the inventive activity via electrodes.

Due to the low heat capacity of the glass of 1.26 kJ/kg°C glass, the amount of energy required to raise a volume of glass to a specified temperature is relatively low in this temperature range. Consequently, the surfaces of the electrodes do not have to be very large as the entire volume of energy fed thereinto does not take up very high values, as stated above.

However, it is important that an even cross-sectional distribution of the electrodes is given in order to achieve an overall fluidisation. This is achieved much better with base electrodes standing in a row than with side electrodes. It has been found that the backflow is once again retarded by the fact that the electrodes cause an upward movement over the step, so that only comparably small volumes of glass are transported back into the bubbler area.

The invention also relates to a glass melt furnace for producing high melting glasses with evaporable components, in particular of glasses of the group boron glasses and boron silicate glasses, with a longitudinal furnace axis (A-A), a top furnace with a combustion chamber without inner separating walls, with torches for fossil fuels and with a melting tank comprising a melting area, a tank base and in front of a protruding part and a passage to a discharge element a stepped base elevation which is continuous over the entire width of the melting tank.

In order to achieve the same object, such glass melting furnace is according to the invention characterised in that

a) the base elevation is a refining bank with an upstream step which is at least 150 mm high and height "H1" of which lies between 0.3 and 0.7 times height "H2" of the refining bank, and from the top of the step at least one row of booster electrodes extending transversely to the longitudinal axis of the furnace (A-A) protrudes upwards;

b) upstream of the step is arranged at least one row of bubblers positioned in the tank base; and

c) the refining bank along the longitudinal axis of the furnace (A-A) has a length "L2" between 800 mm and 2,000 mm and in height a distance "T" of maximum 300 mm of a structurally provided melt mirror.

In view of further designs of the object of the invention, it is then again particularly advantageous if the following structural demands are met, either individually or in a combination:

- Distance "T" of the horizontal top of the refining bank from the structurally provided melt mirror lies between 100 mm and 175 mm, and length "L2" of the refining bank in the direction of the longitudinal axis of the furnace (A-A) lies between 1,000 mm and 1,500 mm;

- The ratio of length "L1" of the step to length "L2" of the refining bank, as seen in the direction of the longitudinal axis of the furnace (A-A), lies between 0.4 and 0.6;

- When arranging a row of booster electrodes, their axes lie on a straight line which lies at distance "L3" of (0,4 to 0,6) x "L1" from the front edge of the step;

- The booster electrodes are composed of groups of three which are to be supplied with three-phase current and which are electrically switched in sequence "R-S-T" or alternatively singlephased;

- The bubblers are at distance "d" of between 300 mm and 600 mm between each other, and the bubbler row is at distance "L4" of (0.3 to 0.6) x "L1" from the front edge of the step;

- The glass melting furnace is designed as a transverse flame furnace;

- A field of base electrodes is arranged in the melting area.

The distance of, or closeness between bubbler and booster electrodes per unit of length (transversely to the flow direction of the melt) and the distance of the row(s) of bubblers from the step or

refining bank (in the flow direction of the melt) can be determined by way of experimentation.

An exemplary embodiment of the object of the invention will now be described in more detail, based on Figures 1 and 5.

Shown are, in

Figure 1: a vertical longitudinal cross-section through the complete furnace along the longitudinal axis of the furnace (A-A) in Figure 2;

Figure 2: a top view of the melting tank of Figure 1 with the top furnace removed;

Figure 3: the righthand part of Figure 1, at an enlarged scale;

Figure 4: a perspective partial illustration of the object as in Figure 3; and

Figure 5: a section of Figure 3, again at an enlarged scale.

Figures 1 and 2 illustrate a furnace 1 comprising a melting tank 3 and a top furnace 4 with a combustion chamber 2 which is sealed on the delivery side with inserting machine 5 by a first end wall 6 and on the removal side with passage 7 by a second end wall 8. In the side walls are rows of torches 9, some of which are diagrammatically shown in Figures 3, 4 and 5. Torch gases escape through an opening 10 in one of side walls 11, i.e. they are ducted in a counter-flow to a glass melt 12 with a melt mirror 13 and delivered material floating thereon. As illustrated, top furnace 4 is smooth below its arched top in the manner of a "unit melter", i.e. it has no internal separating walls.

Melting tank 3 has at the beginning an even base 3a and a square outline and comprises the following areas or sections, as seen from left to right: adjacent to melt part 14 is a base elevation 15 composed

of step 16 and refining bank 17, both of which extend over the full width of melting tank 3 (Figure 2). On the other side of base elevation 15 follows a protruding part 18 from where passage 7 leads to a discharge part 19 which is connected to feeders (not illustrated) with discharge points at their ends (arrow in Figure 2, right).

Top sides 16a and 17a of step 16 and refining bank 17 are formed by horizontal plane surfaces of which plane "E-E" is particularly highlighted in Figures 3, 4 and 5. Step 16 and refining bank 17 have straightlined front edges 16b or 17b and perpendicular front surfaces 16c and 17c (Figure 3).

Three rows of four each base electrodes 20 are located in melting area 14, and these rows extend vertically to the longitudinal axis of the furnace (A-A), and the gaps increase in the flow direction (from left to right). The outlines of the outer electrodes form a "field". In front of step 16 in base 3a is a row of six bubblers 21, and six booster electrodes 22, which are poled in sequence "R-S-T / R-S-T" or connected to three single-phase transformers, protrude upwards from top side 16a of step 16 (Figure 2).

Figures 3 and 4 clearly verify the following: Booster electrodes 22 protrude from a respective cooled support 23 vertically upwards to just below level "E-E"; however, they can also protrude beyond this plane and even reach as far as melt mirror 13. Melting bath depth "h" is for example 800 mm; distance "T" between plane "E-E" and melt mirror is for example 125 mm, i.e. refining bank 17 has a height "H2" of 675 mm. Step 16 in front thereof has a height "H1" of for example 400 mm (Figure 5).

Figures 4 and 5 give the following complementary illustrations: equidistally spaced bubblers 21 lie on a straight line 21a (broken line) and are spaced between 300 mm and 600 mm from each other, and line 21a has a distance "L4" of approximately 0.5 x "L1" from front edge 16b of step 16. Booster electrodes 22, which are also equidistally spaced, lie on a straight line 22a (broken lines) and are

similarly spaced from each other. Line 22a lies in the middle of step 16 and has a distance "L3" of approximately 0.5 x "L1" from front edge 16b of step 16, although in the opposite direction.

The row of bubblers 21 generates, amongst other things, a strong flow roll in the direction of the feed end of furnace 1, thus preventing entry of unmolten charge material into the area of step 16. However, the effect on the flow by bubblers 21 via step 16 is substantially less. At this point, booster electrodes 22 are effective by means of their own thermal flow rolls which severely heat up the glass melt located above step 16 due to relatively low effect on the flow by bubblers 21, so that it transfers to refining bank 17 where it is effectively refined without necessitating excessive heating by fossil fuel.

This screening effect is stronger the higher the step above tank base 3a (dimension "H1") is relative to the height of the refining bank above tank base 3a (dimension "H2"). Height "H1" of the step find its limit at 0.7 times height "H2" only in that a (small) volume of glass must be present above the step wherein the booster electrodes can develop their effectiveness. For reasons of simplification, gas connections for bubblers 21 and power connections for the booster electrodes have been omitted.

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List of Reference Marks

1	-	Glass Melting Furnace
2	-	Combustion Chamber
3	-	Melting Tank
3a	-	Tank Base
4	-	Top Furnace
5	-	Inserting Machine
6	-	First End Wall
7	-	Passage
8	-	Second End Wall
9	-	Torch
10	-	Opening
11	-	Side Walls
12	-	Glass Melt
13	-	Melt Mirror
14	-	Melt Part
15	-	Base Elevation
16	-	Step
16a	-	Top Side
16b	-	Front Edge
16c	-	Front Surface
17	-	Refining Bank
17a	-	Top Side
17b	-	Front Edge
17c	-	Front Surface
18	-	Protruding Part
19	-	Discharge Part
20	-	Base Electrode
21	-	Bubbler
21a	-	Line
22	-	Booster Electrodes
22a	-	Line
23	-	Support

Patent Claims

1: Process for the manufacture of high melting glasses with evaporable components, in particular glasses of the group of boron glasses and boron silicate glasses with stages of melting and refining a melt (12) in a furnace (1) with a top furnace (4) with a combustion chamber (2) without internal separating walls, with torches (9) for fossil fuels and with a melting tank (3) having a melting area (14), a tank bottom (3a) and in front of a protruding member (18) and a passage (7) to a discharge member (19) a stepshaped base elevation (15) which is continuous over the entire width of the melting tank (3), **characterised in that**

a: a temperature of at least 1,600°C is generated in the upper furnace (4) by delivering to the combustion chamber (2) an oxidation gas containing at least 50 volume percent oxygen;

b: as a base elevation (15) is used a refining bank (17) with an upstream step (16) which is at least 150 mm high and height "H1" of which lies between 0.3 and 0.7 times height "H2" of the refining bank (17), and from the step (16) protrudes in an upward direction at least one row of booster electrodes (22) which extends transversely to the flow direction of the melt (12);

c: the melt (12) upstream of the step (16) is ducted over at least one row of bubblers (21) located in the tank base (3a); and

d: the melt (12) is ducted behind the step (16) with the booster electrodes (22) in a highly heated state over a length of between 800 and 2,000 mm over the refining bank (17), the essentially horizontal top side (17a) of which has a maximum distance "T" of 300 mm from the melt mirror (13).

2: Process according to Claim 1, **characterised in that** a step (16) is used the height "H1" of which above the tank base (3a) is between 0.4 and 0.6 times height "H2" of the refining bank (17) above the tank base (3a).

3: Process according to Claim 1, **characterised in that** the melt (12) is ducted with a mean residence time of between 0.5 and 2.0 hours over the refining bank (17).

4: Process according to Claim 3, **characterised in that** the melt (12) is ducted with a mean residence time of between 1.0 and 1.5 hours over the refining bank (17).

5: Process according to Claim 1, **characterised in that** the melt (12) is ducted in a melt area (14) over a field of ground electrodes (20).

6: Process according to Claim 1, **characterised in that** furnace waste gases are ducted against the horizontal component of the melt flow over the melting stock.

7: Glass melt furnace for manufacturing high melting glasses with evaporable components, in particular glasses of the group of boron glasses and boron silicate glasses, with a longitudinal furnace axis (A-A), a top furnace (4) with a combustion chamber (2) without internal separating walls, with torches (9) for fossil fuels and with a melting tank (3) comprising a melting area (14), a tank base (3a) and in front of a protruding member (18) and a passage (7) to a discharging member (19) a stepshaped base elevation (15) which is continuous over the entire width of the melting tankpot (3), **characterised in that**

a: the base elevation (15) is a refining bank (17) with an upstream step (16) which is at least 150 mm high and height "H1" of which above the tank base (3a) is between 0.3 and 0.7 times height "H2" of the refining bank (17)

above the tank base (3a), and from the top (16a) of the step (16) protrudes upwards at least one row of booster electrodes (22) extending transversely to the longitudinal axis of the furnace (A-A);

b: upstream of the step (16) is configured at least one row of bubblers (21) located in the tank base (3a); and

c: the refining bank (17) has along the longitudinal axis of the furnace (A-A) a length "L2" between 800 mm and 2,000 mm and in height a distance "T" of maximum 300 mm from the structurally provided melt mirror (13).

8: Glass melt furnace according to Claim 7, **characterised in that** distance "T" of the horizontal top (17a) of the refining bank (17) from the structurally provided melt mirror (13) is between 100 mm and 175 mm, and length "L2" of the refining bank (17) in the direction of the longitudinal axis of the furnace (A-A) is between 1,000 and 1,500 mm.

9: Glass melt furnace according to Claim 8, **characterised in that** the ratio of length "L1" of the step (16) and length "L2" of the refining bank (17), respectively seen in the direction of the longitudinal axis of the furnace (A-A), lies between 0.4 and 0.6.

10: Glass melt furnace according to Claim 9, **characterised in that** with an arrangement of a row of booster electrodes (22) their axes lie on a straight line (22a), and this line (22a) lies at a distance "L3" of (0.4 to 0.6) x "L1" from the front edge (16b) of the step (16).

11: Glass melt furnace according to Claim 7, **characterised in that** the step (16) comprises a horizontal top (16a) and a perpendicular front surface (16a).

12: Glass melt furnace according to Claim 7, **characterised in that** the booster electrodes (22) are composed of triple groups to be supplied with three-phase current which are electrically switched in the sequence "R-S-T" or connected to single-phase transformers.

13: Glass melt furnace according to Claim 7, **characterised in that** the bubblers (21) have a distance "d" of 300 mm to 600 mm between them, and the row of bubblers (21) has a distance "L4" of (0.3 to 0.6)x "L1" from the front edge (16b) of step (16).

14: Glass melt furnace according to Claim 7, **characterised by** its design as a transverse flame furnace.

15: Glass melt furnace according to Claim 7, **characterised in that** in the melt area (14) is configured a field of ground electrodes (20).

16: Glass melt furnace according to Claim 7, **characterised in that** in the area of the charge end of the furnace (1) is arranged at least one waste gas opening (19) for the waste gases of the combustion chamber (2).

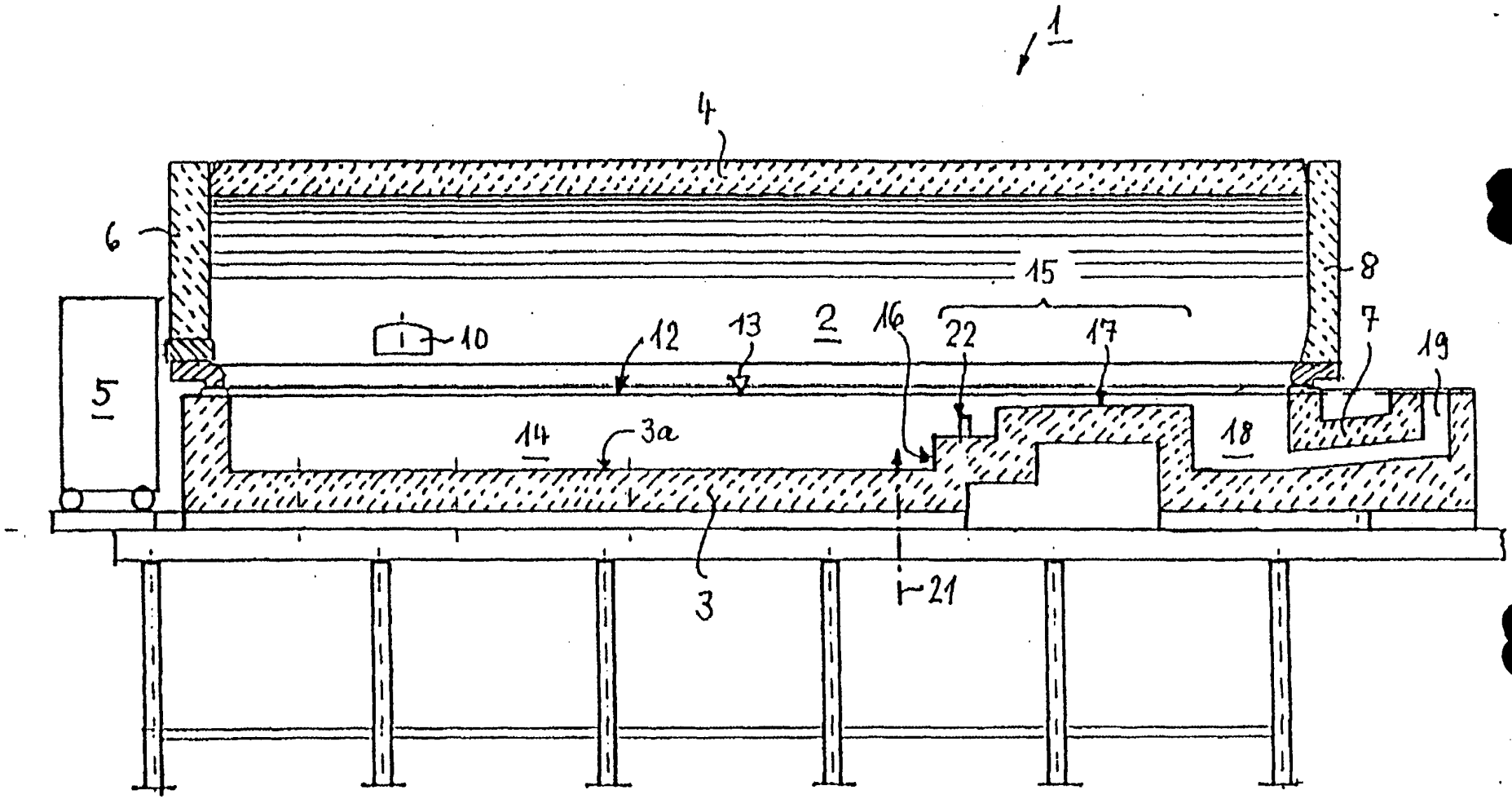


FIG. 1

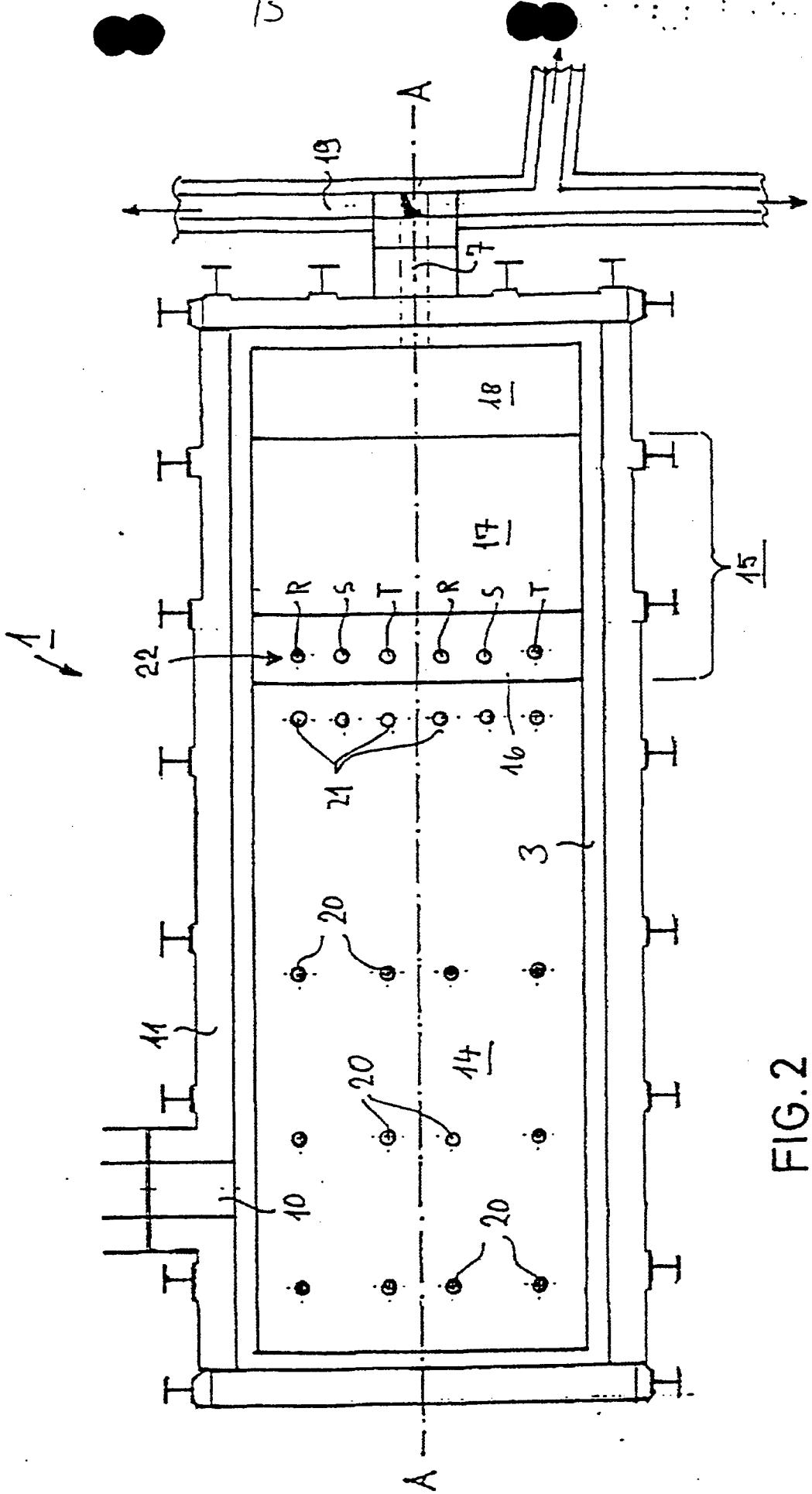


FIG.2

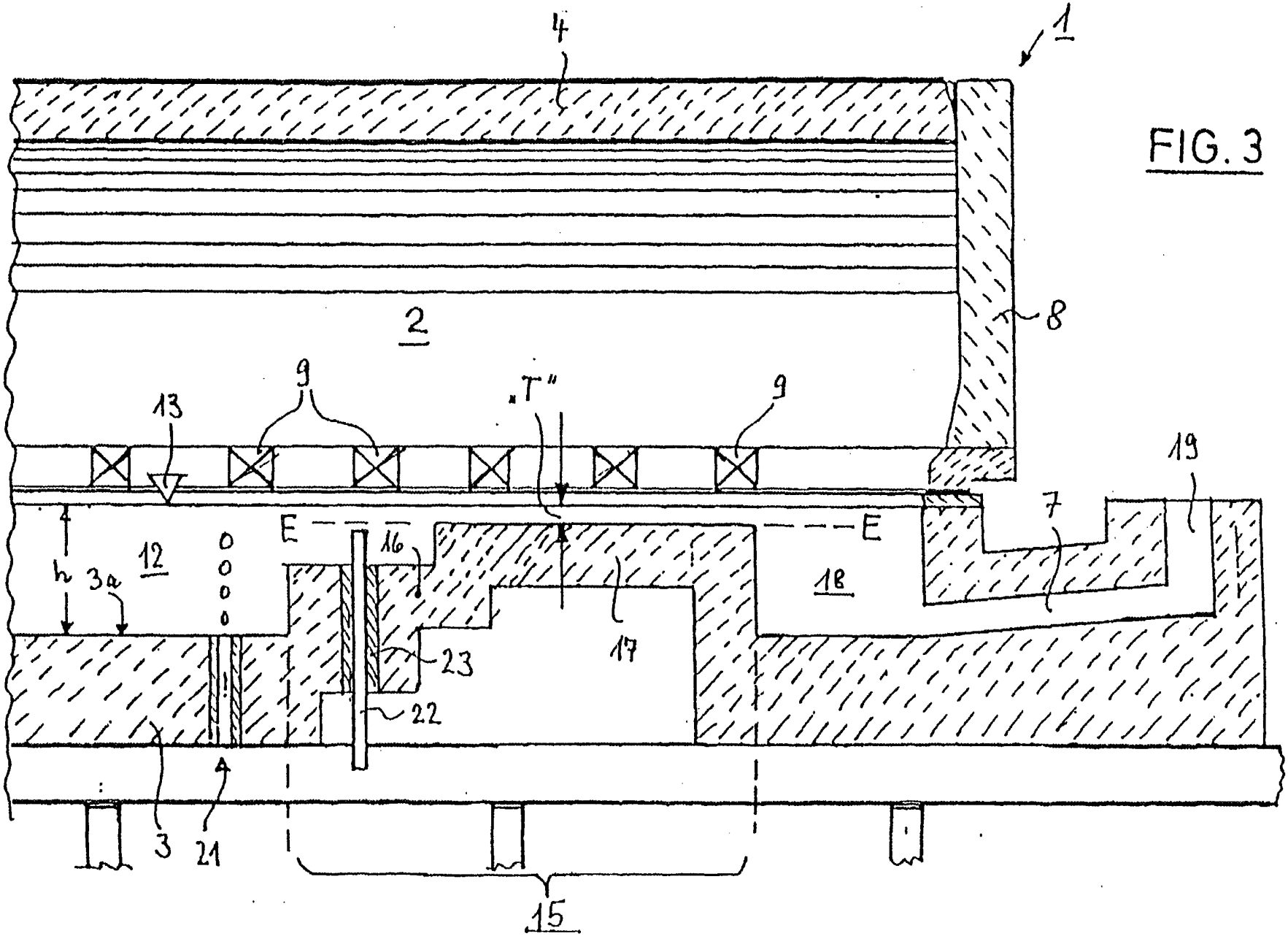


FIG. 3

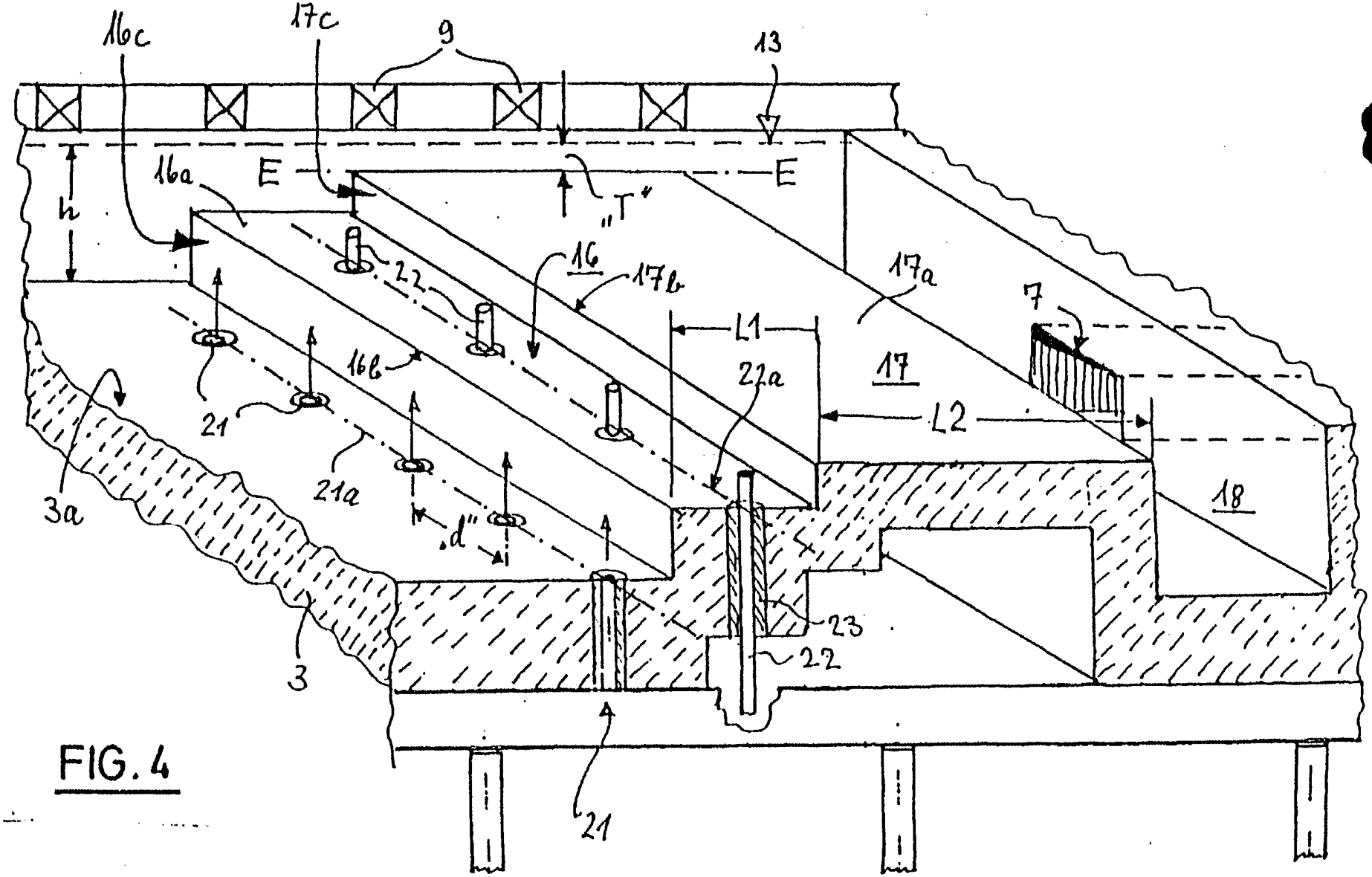
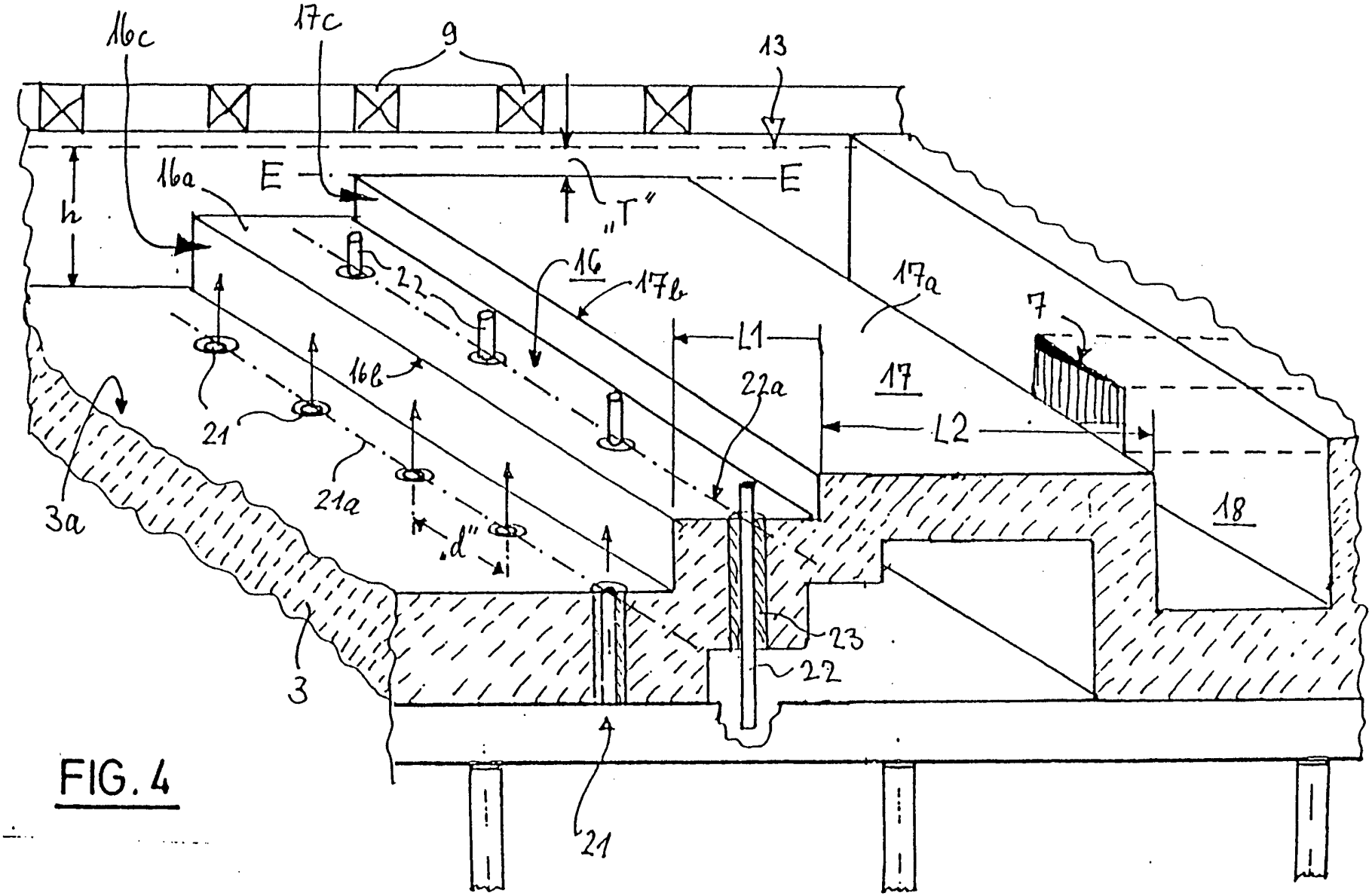

16c
17c
9
13
16a
E
E
h
"T"
16
17b
17a
7
22
L1
17
16b
22a
L2
21
21a
18
3a
d"
23
22
3
21

FIG. 4


16c
17c
9
13
16a
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16
17b
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22
L1
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16b
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21a
18
3a
d"
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3
21

FIG. 4

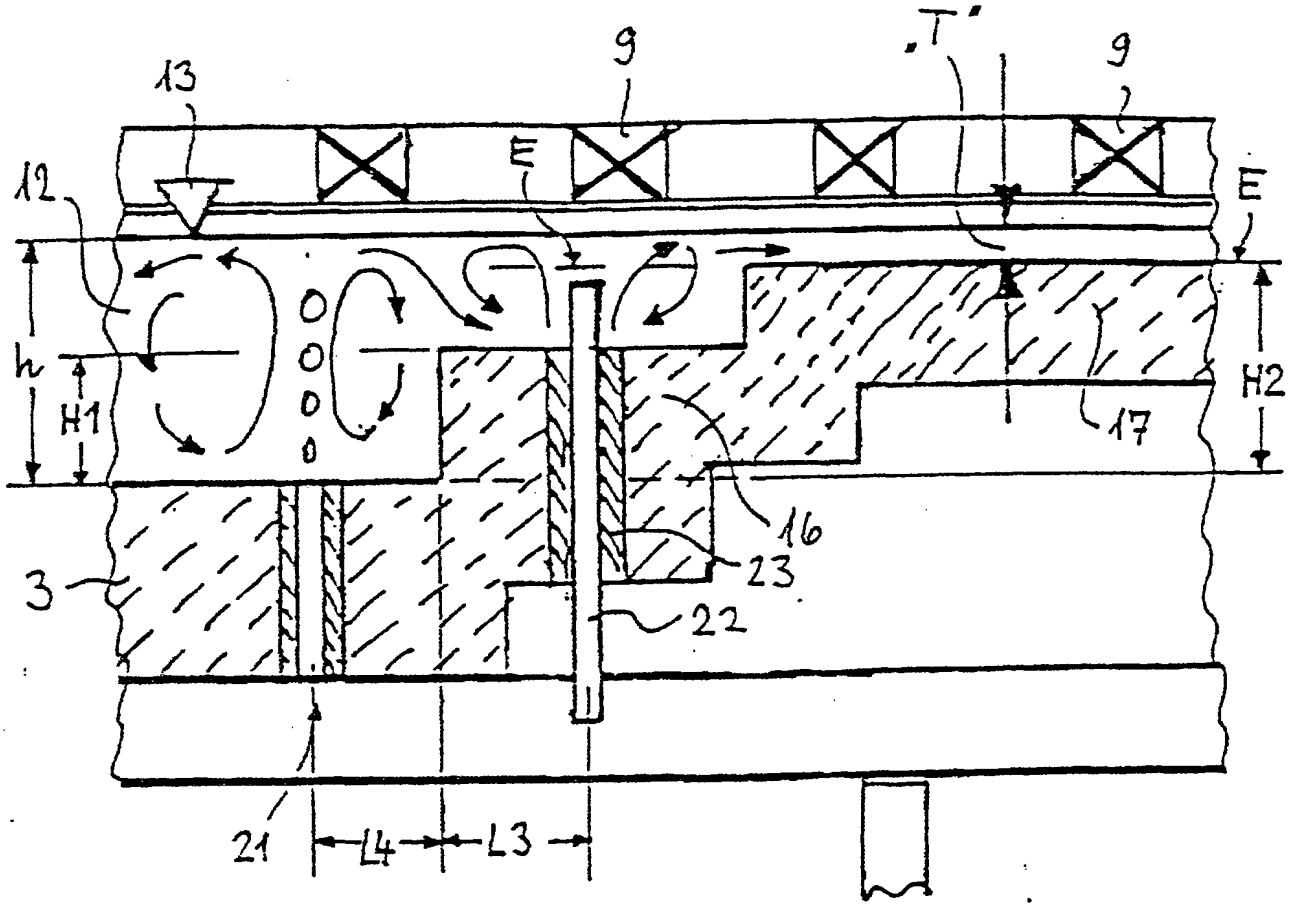

FIG. 5